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*Renewing Canada's Manufacturing Economy: A Regional Comparison, 1973-1996*

by W. Mark Brown

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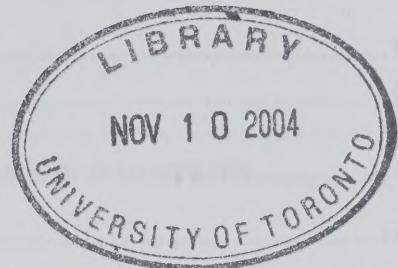
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# Renewing Canada's Manufacturing Economy: A Regional Comparison, 1973-1996

by

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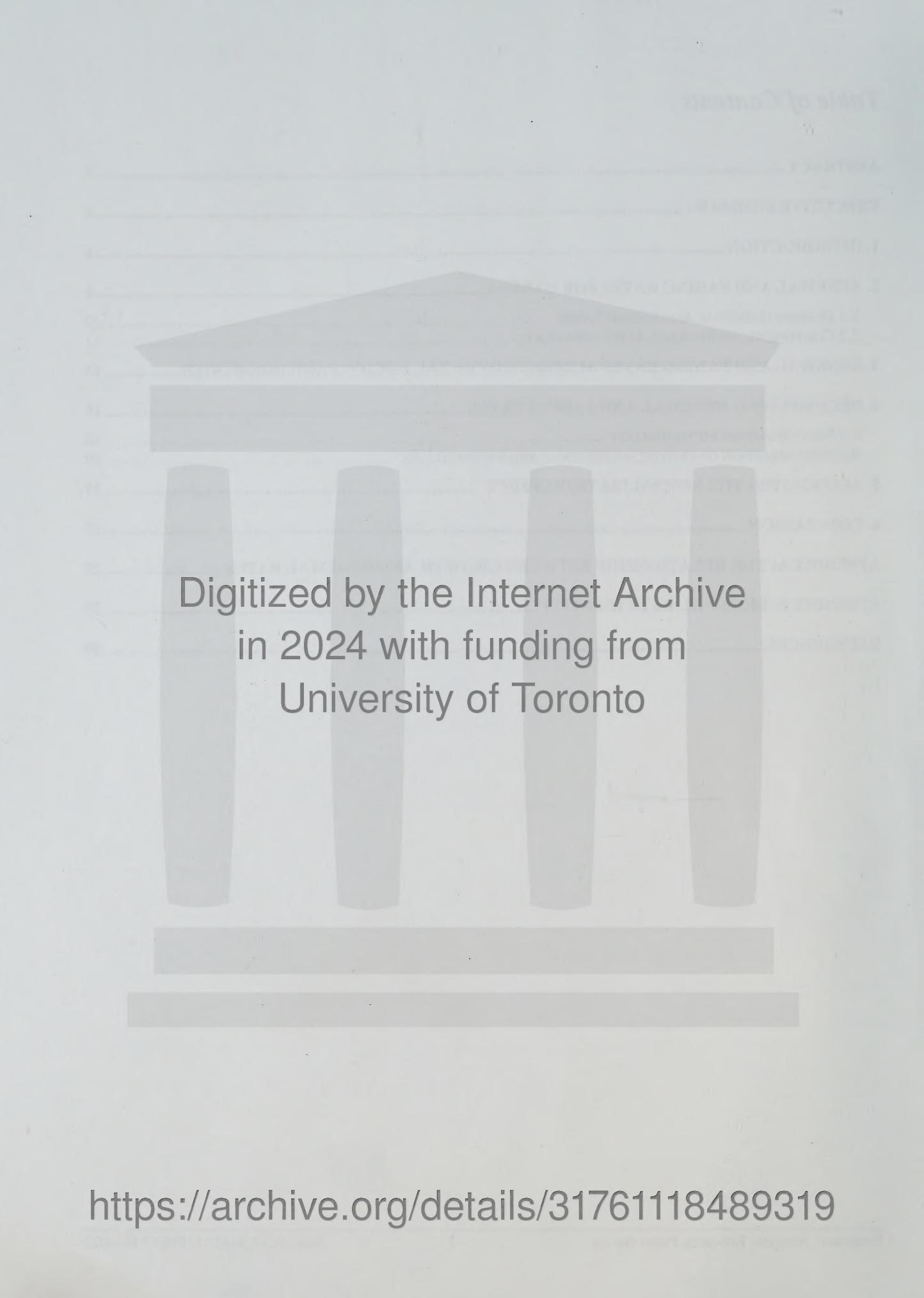
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## Abstract

The primary objective of this paper is to measure the degree of renewal within the Canadian manufacturing economy as a whole and across provinces. Regional economies are continually undergoing adjustment as their firm populations react to changing tastes, technologies, and the challenges of outside competition. Adjustment typically takes place as the stock of jobs is renewed in each industry. This micro-dynamic process of renewal has a substantial impact on the structure of national and regional economies. Using a longitudinal micro-data set—which covers the population of manufacturing plants in Canada from 1973 to 1996—the study shows that the manufacturing sector experienced considerable job renewal. Two-thirds of jobs in 1996 were newly created since 1973. There was considerable variation in provincial renewal rates. A decomposition analysis suggests this variation is not purely an artefact of the types of industries found in provinces, but reflects other characteristics of their economies.

**Keywords:** renewal, creative destruction, manufacturing, regional economics, agglomeration economies, decomposition analysis

## ***Executive Summary***

Economies, be they national or regional, continuously change as they react to shifting tastes and technologies, and the challenges of outside competition. Often, we think of economic change in terms of its net outcome, whether an economy grows or declines. But we can also think of economic change as a more complete process. It can be thought of as the result of, and reflected in, the behaviour of individual businesses.

At any one time the economy is composed of businesses that are succeeding and failing. In this sense, an economy is almost constantly undergoing a process of renewal. Insights into the process of renewal reveal the nature of the competitive process. An economy with little firm entry, exit or market share turnover among competitors is likely to stagnate. The ideas brought by new firms and the competitive pushes of rivals are not present.

This paper measures renewal within the manufacturing sector nationally and across provincial economies. Covering a twenty-three year period (1973-1996), the analysis encompasses a time of considerable change within the Canadian manufacturing sector, including three business cycles and the implementation of the Canada-U.S. free trade agreement.

Renewal rates are measured in terms of jobs that are present in 1996 but not in 1973. These jobs result from the birth of new plants or the growth of employment within continuing plants. Taken as a proportion of employment in 1996, these new jobs provide a measure of the degree to which an economy is new—the extent of its renewal.

There are several questions that this paper seeks to answer regarding renewal.

- 1. What is the extent of renewal within the manufacturing sector?*

Two-thirds of jobs present in 1996 are new since 1973. About 75% of these jobs were created by the establishment of new plants. Economies do not renew themselves by shifting resources between growing and declining plants, but through their outright replacement—economies renew themselves primarily through discontinuous change.

- 2. Is renewal driven by the investments of new or incumbent firms?*

Of the jobs present in 1996 and new since 1973, just over 55% were created by new businesses. New firms, rather than incumbent firms, play the most significant role in the renewal process. Renewal is closely linked to the energy and ideas of, and capital raised by, new businesses.

- 3. Are there significant differences in renewal rates across provincial regions?*

There is considerable variation in renewal rates across provincial regions. Newfoundland and the Maritimes have the lowest renewal rates at 53%, while Saskatchewan and Alberta have the highest at 73% and 79%, respectively. This represents a 26 percentage point difference between the lowest and highest regional renewal rates. The remaining provinces fall near the national average of 63%.

4. *Is the variation in regional renewal rates driven by differences in the industrial makeup of regional manufacturing economies?*

Using a decomposition analysis that controls for the effect of industrial structure, the paper shows that Newfoundland's and the Maritimes' relatively low renewal rates (compared to the Canadian average) result primarily from a larger presence of industries that exhibit inherently low rates of renewal.

In contrast, Saskatchewan's and Alberta's high renewal rates cannot be explained by differences in industrial structures. Their high rates of renewal relate to 'other factors'. Both economies are highly attractive to incumbent and/or new firms to expand or establish new manufacturing plants.

*This process of Creative Destruction is the essential fact of capitalism. It is what capitalism consists in and what every capitalist concern has got to live in.*

Joseph Schumpeter (1975: 83)

## 1. Introduction

Economies, be they national or regional, continuously change as they react to shifting tastes and technologies, and the challenges of outside competition. Often, we think of economic change in terms of its net outcome, whether an economy grows or declines. But we can also think of economic change as a more complete process. It can be thought of as the result of, and reflected in, the behaviour of individual businesses.

In an uncertain world with varying capacities of firms to innovate and grow (Nelson and Winter 1982), there are inevitably both winners and losers. For some firms, the gamble of producing a new product or developing a new production process pays off with higher profits and a larger share of the market. For others, the same gamble fails, resulting in decline, and possibly bankruptcy. Still other firms may decide not to risk change and lose out to competitors with better and cheaper products. The picture that emerges is of an economy that is at any one time composed of businesses that are succeeding and failing. In this sense, an economy is almost constantly undergoing a process of renewal.

Insights into the process of renewal reveal the nature of the competitive process. An economy with little firm entry, exit or market share turnover among competitors is likely to stagnate. The ideas brought by new firms and the competitive pushes of rivals are not present. Without these pressures, firms are not propelled to innovate and grow (Porter 1998). Therefore, by observing the degree to which economies are renewing we are able to gain insight both into their dynamism, and possibly their potential for long-term growth.

This paper measures renewal across provincial economies, specifically within their manufacturing sectors. It covers a twenty-three year period (1973-1996), encompassing a time of considerable change within the Canadian manufacturing sector, including three business cycles and the implementation of the Canada-U.S. free trade agreement. This is a period that provides a genuine test of how much renewal has taken place. It is long enough to identify real, rather than transitory, differences in renewal rates across provincial economies.

Throughout this study, renewal rates are measured in terms of new jobs that were created since 1973. These are jobs that are present in 1996, but not in 1973. New jobs may result from the birth of new plants by new or incumbent firms. They also may result from the growth of employment within incumbent plants. Taken as a proportion of employment in 1996, these new jobs provide a measure of the degree to which an economy is new—the extent of its renewal.

In addition to renewal rates, the analysis also addresses job loss or fading rates, albeit in a more cursory fashion. Fading rates are measured in a similar fashion to renewal rates, except that

losses are measured in terms of jobs that were present in 1973 and not in 1996 as a proportion of 1973 employment.<sup>1</sup>

The paper's other objective, in addition to measuring renewal and fading rates, is to account for why provincial renewal rates differ from each other. In particular, the analysis seeks to determine whether renewal rates vary because the industrial structures of provinces differ or whether there are 'other factors' that make some provincial economies more dynamic than others.

Industrial structure can influence the renewal rate of a province in two ways. The first is that provincial economies may be weighted towards industries with inherently high (low) renewal rates, resulting in overall rates of renewal that are higher (lower) than average. The second and subtler way that industrial structure affects renewal rates is through the effect of geographic concentration of industry itself. The agglomeration of industry in a particular place can generate external economies (see Marshall 1920), which in turn may encourage new entry and incumbent plant growth. Proximity may also generate more intense competition, leading to higher rates of turnover (Porter 1998). Alternatively, the geographic concentration of industry may discourage entry. There is evidence that new firm entry tends to take place away from existing concentrations of industry (Dumais, Ellison and Glaeser 2002). As a consequence, renewal may be low in places that are specialised in an industry and higher in locations where industry is unspecialized.

If provincial renewal rates only differ because of industrial structure, then differences in their renewal rates speak more to the nature of the industries in each region than to other facets of provincial economies. However, if industrial structure is not the driving force behind provincial renewal rates, then there may be other characteristics of provincial economies that determine their level of dynamism. These 'other factors' might include institutional differences (e.g., presence of strong research oriented universities), urban structure (presence of large dynamic cities) and market access (e.g., close proximity to major Canadian and U.S. markets). The purpose of this paper is not to identify the relative important of any one of these factors, but to see in the broadest terms how potentially important they might be.

The remainder of the paper is organized as follows. Section 2 measures the extent of job loss and renewal between 1973 and 1996 for Canada. It also identifies the sources of these fading and renewal rates—that is, the degree to which jobs were lost through firm deaths, plant closures and the downsizing of incumbent plants and gained through the establishment of new firms, plant births by incumbent firms and the expansion of employment within incumbent plants. Section 3 asks whether fading and renewal rates vary across provinces. Using a decomposition methodology, Section 4 measures the effect of industrial endowments on provincial renewal

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1 Renewal and fading rates are closely associated with measures of job creation and job destruction used elsewhere (c.f. Davis and Haltiwanger 1992 and Baldwin, Dunne and Haltiwanger 1998). The only difference is that rates of job creation and job destruction are measured over short periods of time, typically annual or 5-year periods. These short periods are appropriate for addressing questions related to labour market dynamics and their relationship to macroeconomic cycles. But they do not provide us with a picture of the extent of job turnover in the long-run. Renewal and fading rates, because they abstract from the short- to medium-term, provide us with a qualitatively different measure of the underlying dynamics of the economy. They measure the extent to which the growth and decline of incumbent plants combined with the entry and exit of new ones lead to the complete turnover jobs with the economy.

rates. Its purpose is primarily to determine whether provincial renewal and fading rates vary simply because of their unique endowments of industries. As there may be a relationship between geographic concentration and renewal rates, Section 5 explores this effect through an extension of the decomposition methodology developed in Section 4. Section 6 concludes the paper.

## ***2. Renewal and fading rates for Canada***

In the past, it has been argued that the entry of new firms contributed very little to the number of firms in an industry or employment levels (see Birch 1981, Storey 1985 and Johnson 1986). Entrants were typically small and accounted for a small portion of the population of firms and employment in any given year. What is more, it was argued that these new firms exited almost as quickly as they emerged. The picture of the economy that emerges from these studies is one of a core of established firms that account for the vast majority of output and employment and a swarm of small, marginal new firms that are constantly appearing and disappearing (Baldwin 1995).

More recent analyses using longitudinal data suggest this widely held view is false. Over time, the cumulative effect of entry can be substantial. For example, new manufacturing firms that entered between 1970 and 1981 in Canada accounted for 35% of all firms and 10% of employment by 1981 (Baldwin 1995). Therefore, although new entrants have higher exit rates than the population as a whole, some are able to survive and grow. The implication of this is that economies are renewing themselves, in part, by replacing older firms with new ones.

This section has two objectives. The first is to measure the extent and underlying sources of renewal in the Canadian manufacturing sector over a relatively long period of time (1973-1996). The second objective is to measure the degree to which employment has been lost over the same period of time; that is, the proportion of jobs that existed in 1973 that no longer existed in 1996, either because plants were closed or were downsized. These lost jobs might be thought of as the extent to which an economy is constantly fading away and must in turn be renewed to maintain employment. These two measures provide us with a perspective on how dynamic the Canadian manufacturing economy has been—the extent to which the economy is fading away and being renewed.

A longitudinal micro-data set derived from the Annual Survey of Manufacturers (ASM) is utilised to measure rates of renewal and fading. The ASM provides detailed information on employment, industry and geographic location of plants. It follows the population of manufacturing plants for the period from 1973 to 1996. As such, it is possible to determine whether a plant exited or entered over the study period. In addition, it is also possible to determine whether an incumbent plant's employment grew or declined. As will become apparent below, these are the essential ingredients to measure renewal and fading rates.

In addition to information on plant entry, exit and employment growth, the ASM provides information on whether a plant was built by an incumbent or new firm. Therefore, it is possible to make the distinction between renewal that is driven by incumbents or new firms. It is also

possible to determine whether a plant exit resulted in a firm death or whether the firm continued to operate.

## 2.1 Defining renewal and fading rates

Before discussing the extent of gross job gains and losses in Canada, renewal and fading rates first have to be formally defined. Because renewal ultimately implies something has been lost, it is logical to first discuss fading rates.

An economy can lose employment via two channels—plant closures and downsizing (layoffs). Closure is the more dramatic of the two and represents a significant decision on the part of a firm. If it is a single plant firm, a plant closure is synonymous with the firm's death. For multi-plant firms, the closure of a plant may be the result of many factors. The firm may have lost markets for the plant's output. There may be another location, either inside or outside of Canada, which is more profitable. Finally, closure might be the result of technological change that made the old plant obsolete.

Plant downsizing is similar to plant closures because both may be the result of lost markets or the decision on the part of a multi-plant firm to transfer production to other plants. However, downsizing may also be the result of investment in labour saving technology. Therefore, downsizing cannot in every respect be interpreted as an indicator of a plant that is uncompetitive. In some instances, it may indicate the plant has been deemed worthy of new investment.

These two channels of employment loss translate into three components. The first is Firm Exits ( $X^d$ ), which is the sum of employment in year  $t-\tau$  of plants of firms that had exited by year  $t$ . The second component is Plant Exits ( $X^p$ ), which is the sum of employment in year  $t-\tau$  of plants that had exited by year  $t$  of continuing (incumbent) firms. The third component is Decliners ( $D$ ), which is the sum of the net loss of employment for each declining plant between year  $t-\tau$  and  $t$ .

These three components can be used to calculate fading rates ( $f$ ). Fading rates are defined as:

$$f = \frac{X^d + X^p + D}{E^{t-\tau}}, \quad (1)$$

where  $E^{t-\tau}$  is employment in the base year, 1973. The fading rate is the share of jobs in 1973 that no longer existed in 1996. The greater the amount of employment lost as a result of plant closings and downsizing, the higher the fading rate.

The economy gains jobs through two similar yet countervailing channels to employment loss: plant births and growth of employment in incumbent plants. New plants may be built by new firms or incumbent firms. For new firms, a plant birth is the result of a perceived market opportunity. In the case of incumbent firms, the decision to open a new plant is likely the result of one of the following three factors. First, the firm may be expanding into new markets. These may be in the form of new product markets or geographic markets. Second, the firm may be shifting its resources to a more profitable location (e.g., from central cities to the suburbs—see Brown and Baldwin 2003). Finally, technological change may have made older plants obsolete, requiring the firm to build new ones.

The second channel of employment gains is growing employment in incumbent plants. This is the less dramatic of the two channels and might be thought of as the result of incremental changes within plants (e.g., the addition of a new shift).

As with employment loss, these two channels can be divided into three components. The first component is New Firm Births ( $N^n$ ), which is the sum of employment in year  $t$  in the plants of new firms that entered after year  $t-\tau$ . The second component is Incumbent (or Old) Firm Births ( $N^o$ ), which is the sum of employment in year  $t$  in the plants built by incumbent firms after year  $t-\tau$ . The final component is Growers, which is the sum of the net employment gains in plants that grew between  $t-\tau$  and  $t$ .

These three components can be used to define a renewal rate ( $r$ ):

$$r = \frac{N^n + N^o + G}{E^t}, \quad (2)$$

where  $E^t$  is the total employment in year  $t$ . The renewal rate represents the proportion of employment in year  $t$  that did not exist in year  $t-\tau$ . The more new plants are built and/or employment is added to existing plants between  $t-\tau$  and  $t$  relative to the overall level of employment in time  $t$ , the greater is the renewal rate.

Both fading and renewal rates can be thought of as measures of job turnover, which are akin to the measures of job creation and job destruction used by others (c.f. Baldwin, Dunne and Haltiwanger 1998). These two measures of turnover tend to underestimate the degree of job turnover. There are two reasons for this (see Davis, Haltiwanger and Schuh 1993). First, plants, rather than workers, form our fundamental unit of analysis. We are implicitly ignoring job turnover that results from attrition or reallocation of jobs within plants between classes of workers (e.g., computer programmers for production line workers). Second, we measure rates of job renewal and fading between discrete points in time. This only provides a snap-shot of employment at the start and at the end of our study period. As a result, renewal and fading rates are unable to take into account increases or decreases in employment within continuing plants that occurred between these two points in time. Moreover, renewal and fading rates will not measure the entry and exit of plants that occurred during the years that fall between the beginning and end years of the study period.

There is a close relationship between renewal and fading rates and employment growth rates. As equation (3) illustrates,<sup>2</sup> employment growth depends on relative renewal and fading rates:

$$g = \frac{1}{1-r}(r-f). \quad (3)$$

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2 See Appendix A for formal proof.

If the renewal rate is greater than the fading rate, then the economy will experience positive growth. On the other hand, if the fading rate is greater than the renewal rate, employment will decline.

The purpose of this paper is not to relate renewal and fading rates to growth. Nevertheless, it is important to recognise that there is a relationship, and it depends on their *relative* values. A high renewal rate does not mean that a region necessarily will experience high growth since it may also have a high fading rate. Similarly, a low fading rate does not mean a region will grow rapidly, because it may also have a low renewal rate.

Finally, in order to reduce any confusion between measures of rates and levels, rates will be represented by lowercase letters and levels by uppercase letters throughout the discussion.

## ***2.2 Components of renewal and fading rates***

Between 1973 and 1996, manufacturing employment in Canada grew from 1.66 million to 1.70 million or about 2% (see Table 1). Although aggregate employment levels changed little, there was considerable gross loss of employment over the period. Just over 1 million jobs that were present in 1973 were eliminated by 1996. But by 1996, the 1 million jobs that disappeared after 1973 had been replaced. These new jobs effectively renewed two-thirds of the Canadian manufacturing employment.

Employment losses were spread across all three components, decliners, firm exits and plant exits. Seventeen percent of employment was lost because of declining employment in incumbent plants. Twenty-five percent of 1973 jobs were lost because of firm exits. Another 21% was lost because of plant closures by continuing firms. Together these job losses accounted for 63% of employment in 1973 or almost two of every three jobs. It suggests that during the working life of a production worker, even before taking, for instance, attrition into account, it is unlikely that s/he will be able to keep the same job in the same plant. It also implies a high rate of renewal is required to maintain employment.

The prevalence of employment loss through plant closures implies the economy adjusts through discontinuous change—adjustment does not occur incrementally through changes in employment levels in existing plants. This suggests two things. First, there may be considerable experimentation and failure occurring in the economy, particularly since a quarter of 1973 employment was lost because of firm deaths. Second, there may also be substantial shifts in technology, tastes or the geographic location of markets, which result in the obsolescence of some plants.

These large employment losses must be replaced by employment gains for the economy to maintain its employment, which it did over the study period. Most of this new employment has come from entering plants (Births) (see Table 1). These plants accounted for almost half of all employment in 1996 (47%). New employment in continuing plants (Growers) accounted for a much smaller proportion of 1996 employment, 17% or about 1 out of every 6 jobs. Therefore, it was new plants that accounted for the lion's share of new jobs.

**Table 1. Components of fading and renewal rates**

	1973 Employment	1996 Employment	
Decliners [1]	277,222	(17)	
Growers [2]			281,232 (17)
Exits [3]	765,221	(46)	
<i>Firm</i>	419,796	(25)	
<i>Plant</i>	345,425	(21)	
Births [4]			800,759 (47)
<i>New firm</i>			599,431 (35)
<i>Incumbent firm</i>			201,328 (12)
Base	621,201	(37)	621,201 (36)
Total employment	1,663,644	(100)	1,703,192 (100)
Fading [1]+[3]	1,042,443	(63)	
Renewal [2]+[4]			1,081,991 (64)

Note: Renewal and fading rates, and their components, measured in percentage points in parentheses.

Source: Special tabulation, Annual Survey of Manufactures.

Either new or incumbent firms may build these new plants. If new firms exit as rapidly as they enter, then they would account for a relatively small proportion of employment. But if some survive and grow, then the share of jobs created by new firms might be substantial. Entering plants owned by incumbent firms did not create the majority of entrant jobs. Incumbent firm entrants accounted only for 12% of 1996 employment (see Table 1). Plants opened by new firms—firms that came into existence after 1973—accounted for 35% of employment in 1996. New firm formation is a very important part of the employment renewal process.

Finally, also reported in Table 1 is the employment base (Base). These are the jobs that were neither lost nor gained over the study period. The Base accounted for just over one-third of jobs in both periods.

It is evident that the Canadian manufacturing economy has experienced high rates of employment loss and renewal over the past three decades. This process has been driven by high rates of plant exit and entry, and especially entry by new firms. This confirms other recent longitudinal work (e.g., Baldwin 1995) that suggests new firm entry is an important source of job creation. Economies renew their employment base not primarily because older, incumbent firms expand their employment or build new plants. It is, rather, the new firms that play the most significant role.

### ***3. Renewal and fading rates across provincial regions and industries***

This section examines the degree of variation in renewal and fading rates across provincial regions (seven provinces and the Maritimes<sup>3</sup>). It also examines the variation in renewal and fading rates across industries. If there is a high degree of variation in renewal and fading rates across industries, then it may be that industrial structure underlies regional differences in renewal and fading rates.

Outlined in Table 2 are the renewal and fading rates for each provincial region, and their respective deviations from national renewal and fading rates. Also included in the table are the employment growth rates of provincial regions for the period 1973 to 1996. Although the primary focus of this paper is not on growth *per se*, growth rates are included in Table 2 to provide some perspective on the relationship between renewal and fading rates and employment growth noted above.

Of the eight regions reported in Table 2, Newfoundland and Quebec were the only ones that experienced declining manufacturing employment levels between 1973 and 1996. Newfoundland's manufacturing employment fell by 22% and Quebec's by 7.8%. Four other regions—the Maritimes, Ontario, Manitoba and British Columbia—experienced slow growth (less than 10%) over the study period. Finally, Saskatchewan and Alberta experienced the highest growth rates, 42% and 89% respectively.

These different rates of growth observed across provincial regions are reflected in their renewal and fading rates (see Table 2). In western Canada, the two fastest growing provinces, Alberta and Saskatchewan, had relatively high renewal rates. Their fading rates were close to national levels, which suggest their growth was primarily driven by high renewal rates. In contrast, for Manitoba and British Columbia, their relatively modest growth rates were driven not by high levels of renewal but by relatively low fading rates.

Canada's two most important manufacturing provinces, Ontario and Quebec, followed different paths. Ontario saw a slight increase in its employment while Quebec's employment declined by 8%. Partially reflecting Ontario's dominance of the manufacturing sector, its renewal and fading rates differed little from national rates. Quebec's declining employment was associated with a high fading rate, not a low rate of renewal. Quebec was renewing its employment base at the same rates as the nation as a whole, but this was not enough to compensate for employment losses.

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<sup>3</sup> Nova Scotia, Prince Edward Island and New Brunswick are combined together primarily because they are relatively small provinces that form an integrated economic region. Newfoundland and the Maritime provinces might also have been combined to form Atlantic Canada, but since they are geographically separate, and Newfoundland's manufacturing economy is more specialized in fish processing, it was decided not to combine them.

**Table 2. Employment renewal, fading and growth rates by provincial region, 1973-1996**

	Renewal rate	Deviation <sup>a</sup>	Fading rate	Deviation <sup>a</sup>	Growth rate
percent					
Newfoundland	53.2	-10.3	63.4	0.7	-21.8
Maritimes	53.5	-10.0	50.8	-11.8	5.8
Quebec	64.1	0.6	66.9	4.2	-7.8
Ontario	62.2	-1.3	61.9	-0.8	0.8
Manitoba	61.2	-2.4	58.1	-4.6	7.9
Saskatchewan	73.2	9.7	62.0	-0.7	42.2
Alberta	78.8	15.2	59.8	-2.9	89.4
British Columbia	63.3	-0.2	60.4	-2.3	8.1
Canada	63.5	0.0	62.7	0.0	2.4

<sup>a</sup>Deviations are from the national rate (63.5%).

Source: Special tabulation, Annual Survey of Manufactures.

The Maritimes and Newfoundland experienced very different employment growth trajectories between 1973 and 1996. The Maritimes experienced modest growth, but Newfoundland saw dramatic losses of employment over the period. In one respect, however, the two provincial regions were similar. They both had very low renewal rates. The key difference between the two was that the Maritimes' low renewal rate was matched by an even lower fading rate, while Newfoundland's fading was much higher than its renewal rate.

Beyond the specifics of the relationship between renewal and fading rates and growth across provinces, a broader point to be drawn from Table 2 is that the level of renewal or fading alone does not determine whether a region experiences positive or negative growth. The case of Newfoundland and the Maritimes is illustrative. Both have almost equally low renewal rates, but very different growth rates. A low renewal rate does not mean that a region is in decline. But neither does a high renewal rate guarantee high growth. Quebec has the third highest renewal rate, yet it lost employment over the study period because it had a high fading rate.

If renewal and fading rates vary across provinces, then this may be due to differences in the industrial mixes of their respective economies. This possibility can only be true if there is significant variation in renewal rates across industries. Previous studies have shown that industries tend to have different rates of entry and growth and decline and exit in the United States (Dunne, Roberts and Samuelson 1988) and Canada (Baldwin, Dunne and Haltiwanger 1998). Therefore, it is worthwhile to establish here the magnitude of the variation in renewal and fading rates across industries.

Renewal and fading rates by 2-digit industry are reported in Table 3, as well as their deviations from national renewal rates. Renewal is highest in Plastic Products Industries, with almost 80% of jobs in 1996 being new since 1973. The lowest renewal rate by far was in Tobacco Products, where only 4% of jobs were new. The second lowest renewal rate was for Paper and Allied Products, whose rate was nearly 30 percentage points below the national renewal rate. Of the twenty-two industries reported in Table 3, ten had renewal rates that were greater than ten percentage points above or below the national renewal rate. In short, there was considerable variation in renewal rates across industries.

**Table 3. Employment renewal, fading and growth rates by industry (2-digit SIC), 1973-1996**

Industry	Renewal		Fading rate	Deviation <sup>a</sup>	Growth rate
	rate	percent			
Food industries	61.0	-2.5	60.8	-1.9	0.5
Beverage industries	41.5	-22.1	62.2	-0.5	-35.4
Tobacco products industries	4.2	-59.3	66.5	3.8	-65.0
Rubber products industries	56.7	-6.8	50.7	-12.0	14.0
Plastic products industries	79.5	16.0	54.9	-7.7	119.9
Leather and allied products industries	58.4	-5.1	83.2	20.6	-59.7
Primary textile industries	35.2	-28.4	70.9	8.3	-55.2
Textile products industries	65.5	2.0	70.0	7.3	-12.8
Clothing industries	67.2	3.7	79.4	16.8	-37.2
Wood industries	67.6	4.0	63.8	1.2	11.5
Furniture and fixture industries	79.4	15.9	77.4	14.7	9.8
Paper and allied products industries	32.4	-31.2	40.2	-22.4	-11.6
Printing, publishing and allied industries	69.8	6.3	56.5	-6.2	43.9
Primary metal industries	33.6	-29.9	49.6	-13.0	-24.1
Fabricated metal products industries	77.2	13.6	70.4	7.7	29.8
Machinery industries	75.5	11.9	69.5	6.9	24.1
Transportation equipment industries	62.2	-1.3	52.4	-10.2	25.8
Electrical and electronic products industries	69.1	5.6	72.7	10.0	-11.4
Non-metallic mineral products industries	57.8	-5.7	65.3	2.6	-17.7
Refined petroleum products and coal products industries	53.8	-9.8	57.3	-5.4	-7.6
Chemical and chemical products industries	60.6	-2.9	57.9	-4.7	6.7
Other manufacturing industries	77.0	13.4	73.2	10.5	16.3
<i>Canada</i>	<i>63.5</i>	<i>0.0</i>	<i>62.7</i>	<i>0.0</i>	<i>2.4</i>

<sup>a</sup>Deviations are from the national rate.

Source: Special tabulation, Annual Survey of Manufactures.

Fading rates also deviate significantly from the national fading rate. The highest fading rate was in Leather and Allied Products, with a rate of 83% and the lowest rate was in Paper and Allied Products at 40%. Of the twenty-two industries covered, nine had fading rates that were ten percentage points above or below the national fading rates.

#### **4. Decomposing renewal and fading rates**

At this point in the analysis, we are concerned with identifying why regional renewal rates deviate from the national renewal rate. The discussion from the last section suggests variations in industrial structure may account for this deviation. If true, this would imply that renewal rates vary not because there are differences in the ability of regions to generate new jobs, but because regions simply have different endowments of industries.

From this perspective, whether a region's renewal rate deviates from the national average depends on how large each industry is within its economy and on the renewal rate of its industries. This is because: (1) industrial structure varies across regions and so industries with inherently high or low

renewal rates may be over or under represented, and/or (2) because renewal rates within a region's industries differ from the same industries' respective national rates.

To determine the extent that industrial structure and/or within-industry differences matter, it is necessary to control for one or the other. That is, either we hold within-industry renewal rates constant to their national rates and allow industry mix to vary (condition 1), or we hold industry mix constant to the national mix and allow renewal rates to vary within industries (condition 2). If all of the deviation is accounted for by industry mix, then it is differences in industrial structure only that matter. If provinces had the same industrial structure as Canada, they would have the same rate of renewal. On the other hand, if all of the deviation is due to within-industry differences, then it is relative within industry renewal rates that matter. If provincial industries renewed at the same rates as their national counterparts, their renewal rate would match Canada's.

As will become apparent below, these two conditions may not completely exhaust the deviation between provincial renewal rates and the national rate if both account for part of the deviation. This is because, for example, within-industry differences may be greater in industries that are relatively more important to the local economy. As noted in the introduction, theory suggests renewal and industrial structure may be related and as such provide an additional perspective on why renewal rates vary across provinces.

#### 4.1 Decomposition methodology

The purpose of the decomposition is to account for the effect of industrial structure on renewal rates. This can be expressed as a simple identity (see Appendix B for a derivation):

$$r_{\cdot j} - r_{\cdot \cdot} \equiv \sum_i s_{ij} (r_{ij} - r_{i \cdot}), \quad (4)$$

where  $s_{ij}$  is the share of employment in industry  $i$  in region  $j$  in year  $t$  and the dot (.) indicates the variable has been aggregated across a particular dimension.<sup>4</sup> Equation (4) indicates that the difference between the region  $j$ 's renewal rate and the national rate depends on the sum of the deviation between the renewal rates of the region's industries and the national renewal rate weighted by the employment share of each industry in  $j$ .

To test the effect of differences in industrial structure (*endowment effect*), we have to impose *condition 1*. Under this condition, we control for the effect of differences in within-industry renewal rates by forcing the region  $j$ 's industry renewal rates to equal their respective national-industry renewal rates ( $r_{ij} = r_{i \cdot}$ ). If all of the deviation in renewal rates were due purely to differences in industrial structure, then:<sup>5</sup>

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4 Note that for notational simplicity the superscript  $t$  has been suppressed on  $s_{ij}$ .

5 Note that (5) can also be written as  $\sum_i r_{i \cdot} (s_{ij} - s_{i \cdot})$ , which is a functional form that may be more familiar to some readers. We use (5) instead because it is more closely related to (4).

$$r_{ij} - r_{..} = \underbrace{\sum_i s_{ij} (r_{i..} - r_{..})}_{\text{Endowment Effect}}. \quad (5)$$

In other words, if region  $j$  had the same industrial endowment as Canada, it would have the same renewal rate.

Of course, it may be that differences in within-industry renewal rates account for the deviation. Under *condition 2*, we control for the effect of differences in industrial structure by forcing the regional industry shares to equal their respective national shares ( $s_{ij} = s_{i..}$ ). The effect of within-industry differences is further isolated by differencing the region-industry renewal rates ( $r_{ij}$ ) from industry renewal rates ( $r_{i..}$ ), rather than the national renewal rate ( $r_{..}$ ). If all of the deviation in renewal rates were due purely to the differences in within-industry renewal rates, then:

$$r_{ij} - r_{..} = \underbrace{\sum_i s_{i..} (r_{ij} - r_{i..})}_{\text{Region Effect}}. \quad (6)$$

In other words, if region  $j$ 's industries had the same renewal rates as their national counterparts, region  $j$ 's renewal rate would match the national rate. This can be thought of as the *region effect*, because it excludes the effect of industrial endowments and leaves only the effect of within-industry differences. The *region effect* will be positive if, on average, a region's industries have relatively high renewal rates, evaluated at the national industry share for each industry. The *region effect* can be thought of as representing the effect of 'other' regional characteristics on renewal rates.

In reality, regions vary both in terms of their industry endowments and their within-industry renewal rates. This implies that in order to account for the deviation in a region's renewal rate from the national rate the right hand sides of (5) and (6) should be added together. Yet, this does not completely exhaust the renewal rate deviation. There is a portion that is left. Algebraically, the deviation is only completely exhausted when a covariance-like term is added:

$$r_{ij} - r_{..} \equiv \underbrace{\sum_i s_{ij} (r_{i..} - r_{..})}_{\text{Endowment Effect}} + \underbrace{\sum_i s_{i..} (r_{ij} - r_{i..})}_{\text{Region Effect}} + \underbrace{\sum_i (s_{ij} - s_{i..}) (r_{ij} - r_{i..})}_{\text{Specialization Effect}}. \quad (7)$$

The covariance term combines two effects. It combines the effect of having an endowment that deviates from the national average with the effect of having a region-industry renewal rate that deviates from the national-industry renewal rates. The covariance term might be descriptively termed the *specialization effect*. This is because  $s_{ij} - s_{i..}$  measures the extent to which an industry is overrepresented ( $s_{ij} - s_{i..} > 0$ ) or underrepresented ( $s_{ij} - s_{i..} < 0$ ) within a region's economy, relative to the industries national share.

Our understanding of what underlies the specialization effect can have a profound influence on how we interpret the decomposition. The specialization effect is potentially underlain by two

different factors. First, it may be that a region is simply specialized in industries in which it has high (or low) within-industries renewal rates. If this were true, the specialization effect is much like the region effect. It measures the effect of ‘other factors’ embedded within the region’s economy on renewal rates.

Second, the specialization effect may reflect the influence of the geographic concentration of industry itself on renewal rates. As noted in the introduction, from a theoretical perspective, specialization may have a positive or negative effect on renewal rates. A positive effect can result from the presence of agglomeration economies that encouraged the initial concentration of industries. Access to specialized suppliers, pools of trained labour and knowledge spillovers across firms (Marshall 1920) may encourage new firm entry and the more intense competition that the results from geographic proximity may lead to higher rates of job turnover (Porter 1998). In short, geographic concentration may lead to a more dynamic environment that encourages employment renewal. Simply put, a positive specialization effect may be a reflection of this.

The opposite may also be true. The geographic specialization of industry in a region may dampen renewal. Recent evidence suggests that new firm entry tends to take place away from existing concentrations of industry (Dumais, Ellison and Glaeser 2002). Moreover, new entrants appear to be most attracted to places with a large number of small establishments and less attracted to places that are populated by larger establishments within their industry (Rosenthal and Strange 2003). As a consequence, renewal may be low in places that are specialized in an industry and higher in locations where industry is unspecialized.

If geographic concentration itself drives the specialization effect—be it positively or negatively—then industrial structure and renewal are not independent of each other. This implies the endowment and specialization effects should be added in order to account for this additional influence of industrial structure.

In the end, we are left with a choice of where to allocate the specialization effect. It can be added to the region effect, the endowment effect, or divided between the two. This choice depends crucially on our understanding of what underlies the specialization effect: that is, whether it results merely from a specialization in industries with relatively high (low) rates of renewal or whether specialization itself underlies these high (low) rates. An important side point to be drawn from this is that decompositions are not atheoretical, mechanical accounting devices. They are fundamentally informed by our theoretical understanding of the problem at hand.

In this section, the specialization effect will be treated as separate from the endowment and region effects, allowing us to observe the importance of the specialization effect. The next section will attempt to divide the specialization effect, allocating part to the region and part to the endowment effect.

As with renewal rates, fading rates can be decomposed into endowment, region and specialization effects:

$$f_{ij} - f_{..} \equiv \underbrace{\sum_i s_{ij} (f_{i..} - f_{..})}_{\text{Endowment Effect}} + \underbrace{\sum_i s_{i..} (f_{ij} - f_{i..})}_{\text{Region Effect}} + \underbrace{\sum_i (s_{ij} - s_{i..}) (f_{ij} - f_{i..})}_{\text{Specialization Effect}}. \quad (8)$$

The next section outlines results from the decomposition of renewal and fading rate deviations for the seven provincial regions. Because decompositions can be sensitive to the level of industrial aggregation used, they are calculated using the most detailed (4-digit SIC 1980) level of industrial aggregation.

## ***4.2 Decomposition of provincial renewal and fading rates***

Recall that Newfoundland and the Maritimes were the two provincial regions with renewal rates that were well below the national average. The decomposition indicates that it is their industrial endowment that results in their low renewal rates (see Table 4). In other words, these provincial regions are specialised in industries that have inherently low rates of renewal.

The specialization effect tends to augment the endowment effect. The industries in which both regions are specialised tend to have low relative rates of renewal. Only partially compensating the effect of the endowment and specialization effects is the region effect, indicating that if both provinces had the same industrial structure as Canada, their renewal rates would have been above the national rate.

The other provincial region with a low renewal rate was Manitoba. Unlike the Maritimes and Newfoundland, Manitoba's endowment effect tends to raise its renewal rate—Manitoba is specialised in industries with inherently high rates of renewal. It is Manitoba's region and specialization effects that result in its low renewal rate.

For the two provinces with renewal rates well above the national rate, Saskatchewan and Alberta, the region effect accounts for most of their positive deviation. Therefore, after completely controlling for differences in their industrial endowments, most of Alberta and Saskatchewan's deviations are due to within-industry differences in their renewal rates. Alberta and Saskatchewan's high renewal rates are not because they have industries with inherently high renewal rates (the endowment effect); although this is part of the story (see Table 4).

For the remaining provinces, we observe relatively small deviations from national renewal rates, and therefore, there is little difference to explain. Nevertheless, British Columbia does present an interesting case. Its renewal rate is almost equal to the national rate, suggesting its endowment, region and specialization effects would also deviate little from zero. Although true of the endowment effect, this is not true of the region and specialization effects. Like the Maritimes, British Columbia has a positive region effect and a negative specialization effect, which effectively cancel each other out. This suggests that if employment in British Columbia were allocated across industries as it is nationally, its renewal rate would have been well above the national rate. As it stands, however, British Columbia is specialised in industries that have low renewal rates relative to their respective national industries.

The negative specialization effect observed in British Columbia is an extreme example of what is observed across all of the provincial regions. Renewal is particularly high in industries that are underrepresented and low in industries that are overrepresented in a region. In other words, the most dynamic industries are those that are typically the least important and the most static industries are the ones that are among the most important employers.

**Table 4.** Employment renewal rate decompositon by provincial region, 1996

	Renewal rate	Deviation <sup>a</sup>	Endowment effect percent	Region effect	Specialization effect
Newfoundland	53.2	-10.3	-9.5	6.4	-7.2
Maritimes	53.5	-10.0	-7.3	3.0	-5.7
Quebec	64.1	0.6	-0.9	3.7	-2.2
Ontario	62.2	-1.3	0.9	-1.5	-0.7
Manitoba	61.2	-2.4	2.7	-1.9	-3.2
Saskatchewan	73.2	9.7	1.2	11.5	-3.0
Alberta	78.8	15.2	4.2	12.8	-1.8
British Columbia	63.3	-0.2	-1.9	10.4	-8.7

<sup>a</sup>Deviation from the national rate.

Source: Special tabulation, Survey of Manufactures.

As with renewal rates, fading rates can be decomposed into an endowment effect, a region effect and a specialization effect (see Table 5). The province with the highest fading rate was Quebec, with a positive deviation of 4.2%. It is primarily the endowment effect that accounts for Quebec's high fading rates—Quebec's specialization in industries that have inherently high fading rates largely explains its deviation from the national rate.

The Maritimes' fading rate was the lowest by far of all the provincial regions. Its strong negative deviation is mainly the result of strong negative endowment and region effects. The implication is that the Maritimes has a low fading rate because it is specialised in industries whose renewal rates are inherently low and because there are characteristics of the region's economy that results in lower rates of plant exit and/or loss of employment.

Manitoba's fading rate is the second lowest after the Maritimes and is driven by negative region and specialization effects. Therefore Manitoba's industries have relatively low rates of exit and its manufacturing economy is oriented towards these industries. Manitoba's fading rate would have even been lower if its endowment effect were not positive.

The other provinces with relatively low fading rates are Alberta and British Columbia. Alberta's fading rate is low because of the region and specialization effects. In contrast, for British Columbia, it is its endowment effect that causes its low fading rate. Its region and specialization effects effectively cancel each other out.

Also of interest in Table 5 is that, as with its renewal counterpart, the specialization effect for fading rates is typically negative. This implies employment losses are lower in industries in which a region is specialized and higher in industries in which the region is not specialized. Industrial specialization is associated with lower rates of new job creation (see Table 4) and loss and a lack of industry specialization seems to generate the opposite effect.

**Table 5.** Employment fading rate decompositon by provincial region, 1996

	Fading rate	Deviation <sup>a</sup>	Endowment effect percent	Region effect	Specialization effect
Newfoundland	63.4	0.7	-6.2	2.2	4.8
Maritimes	50.8	-11.8	-4.9	-4.0	-2.9
Quebec	66.9	4.2	2.6	1.6	0.1
Ontario	61.9	-0.8	-0.6	-0.5	0.3
Manitoba	58.1	-4.6	1.8	-5.2	-1.2
Saskatchewan	62.0	-0.7	-0.6	3.1	-3.2
Alberta	59.8	-2.9	1.7	-2.6	-2.0
British Columbia	60.4	-2.3	-4.0	5.4	-3.7

<sup>a</sup>Deviation from the national rate.

Source: Special tabulation, Survey of Manufactures.

As an additional point of comparison between Tables 4 and 5, the region effects for both renewal and fading rates generally tend to have the same sign. Regions whose industries typically have relatively high fading rates also tend to have high renewal rates as well and visa versa. For example, Manitoba's region effect is negative for both renewal and fading rates and Saskatchewan's is positive. Therefore, after controlling for differences in industrial structure, some provincial regions have inherently more/less dynamic economies than others.

## 5. Allocating the specialization effect

The specialization term combines two effects. It contains the effect of having a structure that differs from the industry average and a renewal rate that differs from the industry average. Thus, it is difficult to assign the specialization effect to either the endowment or the regional effects, unless one makes an assumption regarding how the renewal rate reacts to structure. They may be related, but it remains unclear to this point how much. If you believe that all of the deviations in within-industry renewal rates are due to structure, then it all becomes a structural effect—part of the endowment effect. But it may not all do so and then part should be allocated to the region effect.

By running a simple regression it is possible to calculate how much of the specialization effect comes from structure. The regression takes the following form:

$$r_{ij} - r_{i*} = d(s_{ij} - s_{i*}) + \epsilon_{ij}. \quad (9)$$

It measures the responsiveness of within-industry renewal rates deviations to structure. Substituting (9) into the specialization effect term from (8) results in  $d(s_{ij} - s_{i*})^2$ . This term captures the effect of structure on within-industry renewal rates and can be added to the endowment effect. The portion of the specialization effect that remains,  $\sum_i (s_{ij} - s_{i*})(r_{ij} - r_{i*}) - d(s_{ij} - s_{i*})^2$ , should be added to the region effect.

Based on this reallocation of the specialization effect, the endowment and region effects are now composed of two parts. The endowment effect is composed of the effect due to having renewal rates that are higher (lower) because you have industries that normally (at the Canadian average) have high (low) rates of renewal. The remainder comes from being concentrated in industries with even higher (lower) within-industry renewal rates than the average Canadian industry.

The region effect also consists of two parts. The first is the effect that comes from having a higher (lower) renewal rate if the region had the average industry structure. The second is that which comes from having higher (lower) within-industry renewal rates and having a different industry structure. In other words, the second part captures the effect of being concentrated in industries that have high (low) within-industry renewal rates, exclusive of the effect of structure itself on these same rates.

Regressing relative renewal rates on relative shares across all industries and regions provides a point estimate for  $d$  of -0.05.<sup>6</sup> Although suggesting a negative relationship between renewal and specialization, the point estimate is statistically insignificant. This leaves us with two options. The first is to allocate all of the specialization effect to the region effect, since we cannot reject the null hypothesis that  $d = 0$ . The second option is to treat the point estimate of  $d$  as an upper bound of the influence of structure on renewal. The second option provides a test of the sensitivity of our results to the effect of structure on renewal rates.

Panels A and B in Table 6 present the endowment and region effects on the basis that  $d = 0$  and  $d = -0.05$ , respectively. Comparing Panels A and B illustrates that there is little impact on the result if we assume that  $d=0$  or -0.05. In other words, the results are not sensitive to whether we choose the lower or upper bound for  $d$ . The discussion to follow will focus on the case that  $d = 0$ .

The impact of allocating the specialization effect to the region effect is to reduce the region effect in all instances, but the result of this procedure is not uniformly felt across all regions (see Table 6, Panel A). For Newfoundland and the Maritimes, the region effect changes its sign from positive to negative. Therefore, although when evaluated at the national industry structure the region effect is positive, when we take into account the specialization of these regions in industries with low within-industry renewal rates, the effect of region become negative, albeit only slightly so for Newfoundland. The economies of these regions, in general, have at best a neutral effect on renewal. In Manitoba's case, the reallocation of the specialization effect to the region effect reinforces its already negative region effect. Manitoba's economy tends to discourage renewal. Finally, British Columbia's region effect is reduced substantially. The industries in which it is specialized tend to have low within-industry renewal rates and the effect of this is to substantially reduce the region effect. For the remaining provinces, the reallocation of the specialization effect does reduce their region effect, but not substantially.

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6 The sample used in the regression is restricted to observations where  $r_{ij}$  is greater than 0 and less than 1.

**Table 6.** Employment renewal rate decompositon by provincial region

	Renewal rate	Deviation <sup>a</sup>	Endowment effect	Region effect
percent				
<u>Panel A (d=0):</u>				
Newfoundland	53.2	-10.3	-9.5	-0.8
Maritimes	53.5	-10.0	-7.3	-2.7
Quebec	64.1	0.6	-0.9	1.5
Ontario	62.2	-1.3	0.9	-2.2
Manitoba	61.2	-2.4	2.7	-5.0
Saskatchewan	73.2	9.7	1.2	8.5
Alberta	78.8	15.2	4.2	11.0
British Columbia	63.3	-0.2	-1.9	1.7
<u>Panel B (d=-0.05):</u>				
Newfoundland	53.2	-10.3	-10.4	0.0
Maritimes	53.5	-10.0	-7.4	-2.6
Quebec	64.1	0.6	-0.9	1.5
Ontario	62.2	-1.3	0.8	-2.2
Manitoba	61.2	-2.4	2.6	-5.0
Saskatchewan	73.2	9.7	1.0	8.7
Alberta	78.8	15.2	4.2	11.1
British Columbia	63.3	-0.2	-2.1	1.9

<sup>a</sup>Deviation from the national rate.

Source: Special tabulation, Survey of Manufactures.

The overall picture that emerges is one where on the east coast much of the negative deviation in renewal rates is due to the region's endowment of industries. While in the Alberta and Saskatchewan, it is the ability of their economies to generate high within-industry rates of renewal that accounts for their high renewal rates.

## 6. Conclusion

The underlying premise of this paper is that economies are dynamic—that they experience a high degree of job turnover driven by competition and continuously changing tastes and technologies. For an economy to survive, let alone grow, it must constantly renew its industrial base. The experience of the last three decades has shown that the Canadian manufacturing sector operates within such a dynamic environment of job loss and renewal. Two thirds of jobs present in 1996 did not exist in 1973.

Renewal was driven not by the decisions of incumbent firms to expand employment within pre-existing plants nor by their decision to establish new plants. Rather, it was mainly new businesses that drove the renewal process. Economies renew their industrial bases as a result of the energy and new ideas of new firms.

Provincial regions differ significantly in terms of their renewal and, to a lesser degree, their fading rates. In the Atlantic Provinces—Newfoundland and the Maritimes—it is their

endowment of industries that explains their low rates of renewal. Their industrial structures are heavily weighted towards industries that have inherently low rates of renewal. For the Prairie Provinces—Manitoba, Saskatchewan and Alberta—it is not their industrial endowments that drive their high or low renewal rates. Rather, there are ‘other factors’ that underlie the relatively low rate of renewal found in Manitoba, and the high rates of renewal in Saskatchewan and Alberta. The broad conclusion to be drawn from the decomposition analysis is that it is both industrial structure and the effect of other factors embedded in the region effect that explain differences in renewal rates across provincial regions, and that the relative importance of each differ significantly between Prairie and Atlantic Provinces.

The obvious question that follows from this finding is—what underlies the region effect? One avenue of research would be to identify, in more concrete terms, the effect of differences in institutions, urban structure and market access on provincial renewal rates. Alternatively, it might also be possible to test whether it is jobs created by new businesses or incumbent firms that underlie the region effect. If it is the former, then provinces differ in their ability to generate and sustain new manufacturing businesses. If it is the latter, provinces differ in their ability to attract investment by incumbent firms.

## Appendix A: The relationship between growth and renewal rates

In order to describe the mathematical relationship between growth and renewal rates, the first step is to define employment in both periods as a function of the basic components of renewal and fading rates. Employment ( $E$ ) in year  $t-\tau$  is given by:

$$E^{t-\tau} = X^d + X^p + D + B, \quad (10)$$

where  $B$  is the employment base that is not lost between periods. Similarly, employment in year  $t$  is given by:

$$E^t = N^n + N^o + G + B. \quad (11)$$

The growth of employment between periods then is the difference between (10) and (11):

$$E^t - E^{t-\tau} = (N^n + N^o + G) - (X^d + X^p + D). \quad (12)$$

The net employment growth given by (12) can then be converted into a growth rate ( $g$ ) by dividing through by  $E^{t-\tau}$ :

$$g = \frac{E^t - E^{t-\tau}}{E^{t-\tau}} = \frac{N^n + N^o + G}{E^{t-\tau}} - \frac{X^d + X^p + D}{E^{t-\tau}}. \quad (13)$$

In turn, (13) can be further manipulated such that it is defined in terms of a renewal and fading rate:

$$g = \frac{N^n + N^o + G}{E^t} \frac{E^t}{E^{t-\tau}} - \frac{X^d + X^p + D}{E^{t-\tau}}. \quad (14)$$

The first part of the first term in (14),  $(N^n + N^o + G)/E^t$ , is the renewal rate and the second term is the fading rate,  $(X^d + X^p + D)/E^{t-\tau}$  defined above. Given these definitions of renewal and fading rates, (14) can be re-written as:

$$g = r \frac{E^t}{E^{t-\tau}} - f = r(g+1) - f. \quad (15)$$

Equation (15) can be solved for both growth and renewal rates. Solving first for growth gives:

$$g = \frac{1}{1-r}(r-f). \quad (16)$$

If renewal rates equal fading rates then growth is zero. The higher the renewal rate relative to the fading rate, the stronger the growth rate. Solving for  $r$  illustrates the functional relationship between renewal rates and growth rates and fading rates:

$$r = \frac{g + f}{g + 1} \quad (17)$$

Taking the partial derivative of (17) with respect to  $g$ ,

$$\frac{\partial r}{\partial g} = \frac{1-f}{(1+g)^2} > 0, \quad (18)$$

indicates that renewal rates are a positive function of growth rates, since  $f$  by definition must be less than one. The implication is that renewal rates are a positive function of both growth and fading rates.

## Appendix B: Renewal rate identity

The renewal decomposition is based on the counterfactual premise that each region renews itself at the same rate as the nation as a whole. Its purpose is to account for the effect of the region's industrial endowment on the difference between the real and counterfactual renewal rates. In this appendix, we describe mathematically how this difference can be expressed in terms of a region's underlying industrial endowment as expressed in equation (4).

The first step is to define the actual and counterfactual levels of renewal. In formal terms, the renewal rate of region  $j$  can be defined as:

$$r_{.j} = \frac{N_{.j}^n + N_{.j}^o + G_{.j}}{E_{.j}^t}, \quad (19)$$

where the dot (.) indicates the variable has been aggregated across a particular dimension, in this case industries ( $i$ ). Rearranging (19) such that  $E_{.j}^t r_{.j} = N_{.j}^n + N_{.j}^o + G_{.j}$  gives the actual level of renewal in  $j$ . The counterfactual level of renewal based on the national renewal rate is given by  $E_{.j}^t r_{..}$ .

The difference between the actual and counterfactual levels of regional renewal is then:

$$E_{.j}^t r_{.j} - E_{.j}^t r_{..} = N_{.j}^n + N_{.j}^o + G_{.j} - E_{.j}^t r_{..}. \quad (20)$$

At its root, the decomposition seeks to account for this difference. In this case, we are concerned with the influence of variation in renewal rates across and within industries on the deviation between regional and national renewal rates. This implies the right-hand-side of (20) should be disaggregated by industry:

$$E_{.j}^t r_{.j} - E_{.j}^t r_{..} = \sum_i (N_{ij}^n + N_{ij}^o + G_{ij}) - \sum_i E_{ij}^t r_{..}. \quad (21)$$

By factoring out total employment in region  $j$  on the left-hand-side and employment by industry in region  $j$  on the right-hand-side, (21) becomes:

$$E_{.j}^t (r_{.j} - r_{..}) = \sum_i E_{ij}^t \left[ \left( \frac{N_{ij}^n + N_{ij}^o + G_{ij}}{E_{ij}^t} \right) - r_{..} \right]. \quad (22)$$

Since the fraction within the parentheses on the right-hand-side is a renewal rate for industry  $i$  in region  $j$ , (22) can be re-written as:

$$E_{.j}^t (r_{.j} - r_{..}) = \sum_i E_{ij}^t (r_{ij} - r_{..}). \quad (23)$$

Finally, dividing through by  $E'_{\cdot j}$  allows us to express the identity in terms of renewal rates:

$$r_{\cdot j} - r_{\cdot \cdot} \equiv \sum_i s_{ij} (r_{ij} - r_{\cdot \cdot}), \quad (24)$$

where  $s_{ij}$  is the share employment in industry  $i$  in  $j$ , with the superscript  $t$  suppressed for notational simplicity. Equation (24), which is the same as (4) above, indicates that the difference between the actual and counterfactual renewal rates depends on the deviation between the renewal rates of the region's industries relative to the national renewal rate, weighted by the employment share of each industry in  $j$ .

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